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Relationship between body mass index and the development of cranium in Arak newborns (Central Iran)

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Abstract

Adaptive responses which occur under changing environment enable a species existence during long periods of time. This study aimed at investigating the relationship between body mass index (BMI and characteristic of brain in newborns. This study was undertaken on 1800 healthy live born singletons (822 males and 978 females) routinely delivered at the Gynecology Hospital of Arak Medical Sciences University between 2002 and 2003. Anthropometric data were analyzed by linear regression and regression analysis using SPSS software for Windows (version 15). The results showed that BMI (body mass index) was significantly associated with cerebral index upon adjusting for sex. The strict correlation between BMI and cerebral index suggests that newborn fat deposition may have increased to allow for high myelination in the human brain. The extraordinary fat storage in newborns would be a consequence of the selection for larger brain size in hominid evolution.

Key words

Anthropometry, BMI, Cranium, Iran, Newborns

Introduction

The biological adaptation of animals viewed in a life history theory perspective focuses on the stages of growth from conception to maturity, on the timing of reproductive events, and on the inevitable trade-offs that occur in growth and reproduction (Aiello and Key, 2002; Bogin et al., 2007).

Trade-offs occurs when two traits compete for materials and energy within a single organism or when selection for one trait decreases the value of a second trait (Stearns, 1992).

In this regard, the human being adaptation began with *Homo erectus* who approximately 1.9 million years ago displayed strategies of life similar to *Homo sapiens*. The prominent change was the increased relative brain size that separated *Homo erectus* from australopithecines (Wood and Collard, 1999).

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But a larger brain size demanded for more energy to the encephalon. To solve this problem and comply with the reduced mastication system, the pattern of nutrition changed to high quality and easy to eat diet (Leonard et al. 2007). On the other hand, the longer body size in an erect position and changes in body proportions saved water and energy (Wheeeler, 1993).

Energy is stored principally in fat tissue and in the case of human newborns the percentage of fat tissue is 15% of birth weight which means 3.75% times greater than expected from body size, and 5 times greater than in baboons (Kuzawa, 1998).

The present study was aimed at investigating the relationship between body mass index (BMI) and some anthropometric indices such as brain volume in a sample of healthy human neonates.

Materials and methods

Sample and measurement

A total of 1800 healthy live born singletons (822 males and 978 females) routinely delivered at the Gynecology Hospital of Arak Medical Sciences University between 2002 and 2003 were enrolled for this study, upon informed consent by their mothers. The research was designed following indications of the ethic committee of Arak Medical Sciences University and was supported by a research grant (no 88-72-7) from Arak Medical Sciences University.

Newborns of smoking or diabetic mothers or non Iranian were excluded from the analysis, as were those with known developmental defects. All selected births had occurred between 38 and 42 weeks of gestation. Data collection was performed by the staff of labor room that had been trained to achieve inter observer coherence and was blind to the aim of the research. All information regarding pregnancy, delivery, baby's condition at birth, health, socioeconomic status of the parents and anthropometric data were drafted in check lists which were collected during the first 24 hours after birth. Anthropometric data were obtained according Hrdlička's method as previously described (Ghanbari and Bayat, 2009; Hrdlička, 1939).

The following measures were determined in millimeters by Martin's spreading caliper:

- Head Length (L) = Distance between the glabella to inion point (furthest occipital point)
- Head Breadth (B) = Greatest breadth, right to left
- Head Circumference = Placing a measuring tape round the head, above ears and through the center of eyebrows.
- Auricular Height (H) = Distance from the external auricular meatus to vertex
- The brain volume (in mm^3) was determined by the following formula:
- Brain Volume (BV) for males = $0.000337 \times (L - 11)(B - 11)(H - 11) + 406.01$.
- Brain Volume (BV) for females = $0.000400 \times (L - 11)(B - 11)(H - 11) + 206.60$

Then the following parameters were computed:

- Brain Weight (in grams) = (BV) × (specific brain weight, i.e. 1.035);
- Cerebral Index = 100 × Brain Weight / Body Weight.

Other measures were determined in millimeters by a tape meter without elasticity (precision > 0.1 mm), namely: Head Circumference (the largest occipitofrontal diameter), Thoracic Circumference (the largest thoracic diameter) and Body Length (distance between vertex and heel). The body weight was determined in kilogram by a scale (Sensitivity > 10 g). The data used to compute the following parameters:

- Body Mass Index (BMI) = Body Weight / (Body Length) ^{2};
- Length Index = 100 × Head Circumference / Body Length.

Data analysis

Descriptive statistics were performed and correlations between variables were analyzed separately for boys and girls using SPSS software for Windows (version 15). Pearson's product-moment correlation coefficients between variables were computed. The relation between body mass index (BMI) at birth and cerebral index was investigated by linear regression analysis.

Results

The means and standard deviations of the variables were given for each sex in Table 1. Differences between sexes were significant for weight, brain volume and cerebral index, suggesting a higher proportion of body fat in females newborn than in males. Pearson's correlation coefficients were given in Table 2.

Analysis showed that Body Length and Cerebral Index at birth were indirectly correlated with BMI. On the contrary, BMI was significantly and directly correlated with Length Index and Head Circumference (Table 2).

Discussion

Because of correlation of BMI and the percentage of body fat in the general population (Bouchard 1994), this data is often used as an indirect method to measure body fatness and has been proposed as a simple, accurate, and valid measure of fatness in childhood and adolescence (He et al. 2000; Poskitt 1995).

The direct correlation between Head Circumference and Length Index with BMI and the indirect correlation of BMI with Cerebral Index and Body Length (Table 2)

Table 1 – Mean ± SD of the variables by sex in Arak newborns.

Variations	Males(N=822)	Females(N=978)	p- value
Length	50.21±4.44	49.92±4.66	0.11
Weight	3225.33±503.2	3171.77±485	0.04
BMI	13.12±3.26	13.07±3.27.05	0.29
Head Circum	34.90±1	34.49±0.72	0.07
Length Index	70.07±6.7	68.72±6.82	0.42
Brain volume	637.65±47.75	469.41±40.64	0.002
Cerebral Index	21.19±5.39	15.85±4.02	0.01

Table 2 – Pearson's correlation coefficients between variables in Arak newborns.

	Sex	Length	Weight	BMI	HC	TC	LI	BV	CI
Sex			-.054*		-.226**	-.092**		-.885**	-.493
Length				-.768**			-.959**		
Weight	-.054*			.627**					
BMI		-.768**	.627**		.675**		.749**		-.472**
HC	-.226**						.249**	.242**	.168**
LI		-.959**		.749**	.249**				
BV	-.885**				.242**	.092**			.573**
CI	-.493		-.727	-.472**	.168**	.092**		.573**	

BMI = Body Mass Index, **BV** = Brain Volume, **CI** = Cerebral Index, **HC** = Head Circumference, **LI** = Length Index, **TC** = Thoracic Circumference
* Correlation significant at the 0.05 level (2-tailed), ** Correlation significant at the 0.01 level (2-tailed)

suggest that fat deposition does not increase at the expense of the length growth and is possibly correlated with increasing the size of the brain.

This hypothesis is related to the high need of lipids in newborn humans as an energetic and plastic substrate during its accelerated brain growth period (Martin, 1981). Indeed, the accelerated growth of brain size during the first years of life may help explain why newborns devote roughly 60% of growth expenditure to fat deposition during the early postnatal months (Dufour and Sauter, 2002). Moreover, there is a dramatic increase in white matter volume at term suggesting a possible link between increased brain volume and adipose tissue of newborns (Huppi et al., 1998).

The data parallel those of other authors who have demonstrated that birth weight, which may reflect high levels of fat deposition in the neonate, and birth head size which is in association with cognitive abilities, are a species attribute that would be favored by natural selection that enables humans to attain evolutionary goals (MacDonald, 1997).

In conclusion, we propose that the extraordinary fat storage in human newborns is a consequence of the selection for larger brain size to provide a source for generating extraordinary myelin which is need for increasing cognitive abilities in hominid. However, the data of this research were limited by geographical and ethnical conditions and to test the hypothesis similar studies must be continued in other socio-ecological populations.

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